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# UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No. Y0999-011 (8728-255)  
 First Inventor or Application Identifier Challenger  
 Title Method and System for Efficiently...  
 Express Mail Label No. EL192802989US

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☒ \* Fee Transmittal Form (e.g., PTO/SB/17)  
 (Submit an original and a duplicate for fee processing)
2. ☒ Specification [Total Pages 39] 1  
 (preferred arrangement set forth below)
- Descriptive title of the invention
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to Microfiche Appendix
  - Background of the invention
  - Brief Summary of the invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure
3. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets 5] 1
4. Oath or Declaration [Total Pages 2] 1
- a. ☒ Newly executed (original or copy)
- b. ☐ Copy from a prior application (37 C.F.R. § 1.63(d))  
 (for continuation/divisional with Box 16 completed)
- i. ☐ DELETION OF INVENTOR(S)  
 Signed statement attached deleting  
 inventor(s) named in the prior application,  
 see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

\* NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY  
 FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT  
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5. ☐ Microfiche Computer Program (Appendix)
6. Nucleotide and/or Amino Acid Sequence Submission  
 (if applicable, all necessary)
- a. ☐ Computer Readable Copy
- b. ☐ Paper Copy (identical to computer copy)
- c. ☐ Statement verifying identity of above copies

## ACCOMPANYING APPLICATION PARTS

7. ☒ Assignment Papers (cover sheet & document(s))
8. ☐ 37 C.F.R. § 3.73(b) Statement (when there is an assignee) ☒ Power of Attorney
9. ☐ English Translation Document (if applicable)
10. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
11. ☐ Preliminary Amendment
12. ☒ Return Receipt Postcard (MPEP 503)  
 (Should be specifically itemized)
13. ☐ \* Small Entity Statement filed in prior application, Status still proper and desired (PTO/SB/09-12)
14. ☐ Certified Copy of Priority Document(s)  
 (if foreign priority is claimed)
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16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No: \_\_\_\_\_

Prior application information: Examiner \_\_\_\_\_

Group / Art Unit: \_\_\_\_\_

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## 17. CORRESPONDENCE ADDRESS

☐ Customer Number or Bar Code Label

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or ☐ Correspondence address below

Name	James J. Bitetto				
Address	F. Chau & Associates, LLP 1900 Hempstead Turnpike, Suite 501				
City	East Meadow	State	New York	Zip Code	11554
Country	USA	Telephone	(516) 357-0091	Fax	(516) 357-0092

Name (Print/Type)	James J. Bitetto	Registration No. (Attorney/Agent)	40,513
Signature	<i>James J. Bitetto</i>	Date	4/1/99

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ATTORNEY DOCKET NO. YO999-011 (8728-255)  
Date: April 1, 1999  
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Transmitted herewith for filing is the Patent Application of:

Inventors: James R. Challenger, Cameron Ferstat, Arun K. Iyengar, Paul Reed, Karen A. Witting  
For: METHOD AND SYSTEM FOR EFFICIENTLY CONSTRUCTING AND CONSISTENTLY PUBLISHING WEB DOCUMENTS

Enclosed are: [X] 19 sheets of specification; [X] 1 sheet(s) of Abstract; [X] 19 sheet(s) of claims; [X] 5 sheet(s) of drawing(s)

- [X] An assignment of the invention to International Business Machines Corporation with Recordation Form.  
[X] Declaration and Power of Attorney.  
[ ] A certified copy of a \_\_\_\_\_ application, from which priority under Title 35 USC §119 is claimed.  
[X] Associate Power of Attorney.

The filing fee has been calculated as shown below:

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TOTAL CLAIMS	60 -20 =	40
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[X] Any additional filing fees required under 37 CFR 1.16.  
[X] Any patent application processing fees under 35 CFR 1.17.

Respectfully submitted,

By:

James J. Biletto  
James J. Biletto  
Registration No. 40,513  
Attorney for:  
IBM Corporation  
Intellectual Property Law Dept.  
P.O. Box 218  
Yorktown Heights, NY 10598

**Please address all  
correspondence to:**

F. CHAU & ASSOCIATES, LLP  
1900 Hempstead Turnpike, Suite 501  
East Meadow, NY 11554  
Tel: (516) 357-0091  
Fax: (516) 357-0092

**CERTIFICATION UNDER 37 C.F.R. § 1.10**

I hereby certify that this Application transmittal and the documents referred to as enclosed are being deposited with the United States Postal Service on this date April 1, 1999 in an envelope as "Express Mail Post Office to Addressee" Mailing Label Number EL192802989US addressed to: Assistant Commissioner for Patents, Box Patent Application, Washington, D.C. 20231.

James J. Biletto  
James J. Biletto

METHOD AND SYSTEM FOR EFFICIENTLY CONSTRUCTING AND  
CONSISTENTLY PUBLISHING WEB DOCUMENTS

BACKGROUND OF THE INVENTION

5

1. Field of the Invention

The present invention relates to computerized publication of documents, and more particularly to a method for efficiently constructing and consistently publishing documents on the World Wide Web.

10

2. Description of the Related Art

Web sites often present content which is constantly changing. Presenting consistent information to the outside world without requiring an inordinate amount of computing power is a major technical challenge to Web site designers.

15

Some of the key consistency constraints for publishing Web pages include the following:

- (1) A newly updated Web page should not contain hypertext links to older pages which have not been updated yet.

20

(2) A newly updated Web page should not contain hypertext links to pages which have not been created yet.

(3) In many cases, a Web site should not have some of the pages reflecting current information while other pages reflect older information. Instead, it is desirable to publish all updated pages containing current information in one atomic action.

Therefore, a need exists for a system and method for efficiently constructing documents which provides the capability for updating the documents in accordance with changes in a consistent and atomic matter.

#### SUMMARY OF THE INVENTION

A method, which may be implemented by employing a program storage device, for determining an order in which to construct objects, in accordance with the present invention, includes the steps of providing a plurality of objects, at least one of the objects including a relationship with another object in the plurality of objects, identifying at least one relationship between the plurality of objects, representing the at least one relationship between the

plurality of objects using at least one graph, and  
traversing at least one graph to determine the order in  
which to construct objects in accordance with the at least  
one relationship and an update to at least one of the  
5 objects in the plurality of objects.

In alternate methods, the step of representing the at  
least one relationship between the plurality of objects may  
include the step of representing objects in the plurality of  
objects by nodes and representing the at least one  
10 relationship by at least one connection between nodes. The  
step of traversing at least one graph to determine the order  
may include the step of selecting the order based on one of  
performance and correct construction of the plurality of  
objects. The step of traversing at least one graph to  
15 determine the order may include the step of traversing by  
employing at least one topological sort on the at least one  
graph. The order may be constructed from the at least one  
topological sort. The step of constructing objects may be  
based on the order. The step of publishing at least one of  
20 the plurality of objects may be included. All of the at  
least one of the plurality of objects may be published

together. The step of publishing may include the steps of partitioning the at least one of the plurality of objects into a plurality of groups and publishing all objects belonging to a same group together.

5 In still other methods, the step of publishing all objects belonging to a same group together may include the step of, for at least two of the plurality of groups, publishing all objects belonging to a first group before publishing any objects belonging to a second group. The  
10 step of publishing may include the step of satisfying at least one consistency constraint. The step of satisfying at least one consistency constraint may include the step of delaying publication of a first object until a second object which is referenced by the first object is published. The  
15 first object and the second object may include Web pages and a reference between the first and second objects may include a hypertext link. The step of satisfying at least one consistency constraint may include the step of publishing two compound objects together if the compound objects are  
20 both constructed from at least one common changed fragment.

At least one of the plurality of objects is preferably a Web page.

A method, which may be implemented by employing a program storage device, for publishing a plurality of objects includes the steps of providing a plurality of objects, including compound objects, partitioning at least some of the plurality of objects into a plurality of groups such that if two compound objects are constructed from at least one common changed fragment, then the compound objects are placed in a same group, and publishing all objects belonging to a same group together.

In alternate embodiments, the step of publishing may include the step of, for at least two of the plurality of groups, publishing all objects belonging to a first group before publishing any objects belonging to a second group. The step of publishing may include the step of delaying publication of a first object until a second object which is referenced by the first object is published. The first and the second objects may be Web pages and a reference between the first and the second objects may be a hypertext link. The steps of representing objects by nodes on at least one

graph and representing relationships between the objects by  
connections between the nodes may be included. The  
connections may include an edge between two nodes  
representing compound objects if the two compound objects  
are constructed from at least one common changed fragment.  
The connections may include a directed edge from a first  
node representing a first object to a second node  
representing a second object, if the second object includes  
a reference to the first object. The steps of determining  
if a first compound object and a second compound object  
embed at least one common changed fragment by topologically  
sorting at least part of a graph including dependence edges  
between objects, determining changed fragments needed to  
construct a first object by examining the graph in an order  
defined by the topological sort and constructing a union  
between a second object and changed fragments needed to  
construct the second object for at least one edge which  
begins with the second object and terminates in the first  
object and for which the second object has changed.

In still other methods, the step of performing a  
topological sort on at least part of the at least one graph



for finding strongly connected components may be included.  
The steps of examining objects in an order defined by the  
topological sort, when an unpublished object is examined,  
publishing the unpublished object together with all objects  
5 belonging to a same strongly connected component may also be  
included.

Another method, which may be implemented by employing a  
program storage device, for publishing a plurality of  
objects includes the steps of providing a plurality of  
10 objects, constructing at least one graph, the at least one  
graph including nodes representing objects and edges for  
connecting nodes having relationships, at least some of the  
edges being derived from at least one consistency  
constraint, and finding at least one strongly connected  
15 component in the at least one graph.

In alternate embodiments, the step of publishing a set  
of objects belonging to a same strongly connected component  
group may be included. The step of topologically sorting at  
least part of the at least one graph may also be included.  
20 The steps of examining objects in an order defined by  
topological sorting, when an unpublished object is examined,

publishing the unpublished object together with all objects  
belonging to a same strongly connected component may be  
included. The at least one consistency constraint may  
include delaying publication of a first object before a  
5 second object which is referenced by the first object is  
published. The objects may include Web pages and at least  
one edge between the objects may correspond to at least one  
hypertext link. An edge may exist from a first object to a  
second object in at least one of the at least one graphs if  
10 the second object has a reference to the first object. At  
least one of the consistency constraints may include  
publishing two compound objects together if the two compound  
objects are both constructed from at least one common  
changed fragment.

15       These and other objects, features and advantages of the  
present invention will become apparent from the following  
detailed description of illustrative embodiments thereof,  
which is to be read in connection with the accompanying  
drawings.

## BRIEF DESCRIPTION OF DRAWINGS

The invention will be described in detail in the following description of preferred embodiments with reference to the following figures wherein:

5           FIG. 1 is a block diagram showing relationships among a set of fragments and compound objects.

FIG. 2 is a block/flow diagram of a system/method for efficiently constructing and publishing objects in accordance with the present invention;

10           FIG. 3 is a block diagram showing a relationship between a set of fragments and compound objects in accordance with the present invention;

15           FIG. 4 is an object dependence graph (ODG) corresponding according to FIG. 3, in accordance with the present invention; and

FIG. 5 is a flow diagram for a method for consistently publishing objects in accordance with the present invention.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

20           This invention presents a system and method for publishing documents, for example Web documents, efficiently

and consistently. This method may be used at a wide variety of Web sites of the World Wide Web. The present invention may be applied to systems outside the Web as well, for example, where compound objects are constructed from fragments. A fragment is an object which is used to construct a compound object. An object is an entity which can either be published or is used to create something which is publishable. Objects include both fragments and compound objects. A compound object is an object constructed from one or more fragments.

In generating Web content, publishable Web pages known as servables may be constructed from simpler fragments. A servable is a complete entity which may be published at a Web site. Publishing an object means making it visible to the public or a community of users. Publishing is decoupled from creating or updating an object and generally takes place after the object has been created or updated. It is possible for a servable to embed a fragment which in turn embeds another fragment, etc.

While fragments significantly increase the capabilities of a Web site, a number of problems may arise which need to be solved, including the following:

(1) When changes to underlying data occur, how does the system determine all objects affected by the change?

(2) How does the system determine a correct and efficient order for updating fragments and servables?

(3) How can a system consistently publish Web pages in the presence of fragments? For an illustrative example, refer to FIG. 1. Suppose that servables S1 and S2 both embed the same fragment f1. If f1 changes, updated versions of S1 and S2 must be published concurrently; otherwise, the site will look inconsistent. However, the consistency problem is worse than just determining if a set of pages all embed the same fragment. For example, suppose S1 and S3 both embed fragment f2. If f2 changes, updated versions of both S1 and S3 must be published concurrently. However, if both f1 and f2 change, updated versions of S1, S2, and S3 must be published concurrently, even though S2 and S3 might not embed a common fragment.

A method for solving problem (1) is described in a commonly assigned patent application, U.S. Serial No. 08/905,114, entitled "Determining How Changes to Underlying Data Affect Cached Objects" by J. Challenger, P. Dantzig, A. Iyengar, and G. Spivak. The current invention solves problems (2) and (3).

It should be understood that the elements shown in FIGS. 2 and 5 may be implemented in various forms of hardware, software or combinations thereof unless otherwise specified. Preferably, these elements are implemented in software on one or more appropriately programmed general purpose digital computers having a processor and memory and input/output interfaces. Referring now to the drawings in which like numerals represent the same or similar elements and initially to FIG. 2, a block/flow diagram of a system/method for efficiently constructing and publishing one or more servables in accordance with the present invention is shown. In block 100, the system maintains an object dependence graph (ODG) which is a directed graph with objects corresponding to nodes/vertices in the graph. A dependence edge from a to b, for example, indicates that a

change to object a also affects object b. The edge also implies that a should be updated before b after a change which affects the values of both a and b occurs.

Dependence edges may preferably be used to identify the following:

- a. The objects affected by a change to underlying data.
- b. The order in which objects are desired or needed to be updated.

In one illustrative example, FIG. 3 depicts 3 Web pages, P1, P2, and P4. P3 is a fragment embedded in P1 and P2. Similarly, P0 is a fragment embedded in P4. An arrow "A" from P1 to P4 indicates that P1 has a hypertext link to P4. In the illustrative example, FIG. 4 depicts an object dependence graph (ODG) corresponding to the objects in FIG. 3. The ODG indicates that any change to P0 also changes the value of P4. It also indicates that any change to P3 also changes both P1 and P2. Since P4 includes P0, P0 should be constructed before P4 when P0 changes. Similarly, P3 should be updated before both P1 and P2 when P3 changes.

Whenever objects change, the system is notified in block 110. The system will be notified of a set of objects

C which have changed. Changes to objects in C will often imply changes to other objects as well; the system applies graph traversal algorithms to detect all objects which have changed and an efficient order (or partial order) for computing changed objects. In block 120, a set of all objects S affected by the change is determined by a topological sort (or partial sort ) of all (or some) nodes reachable from C by following edges in the ODG. Topological sorting of S orders the vertices so that whenever there is a path from a to b, a appears before b. A topological sorting algorithm is presented in *Introduction to Algorithms* by Cormen, Leiserson, and Rivest, MIT Press, 1990, Cambridge, MA, incorporated herein by reference. Other topological algorithms may also be employed.

In block 130, objects in S are updated in an order consistent with the topological sort performed in block 120. In block 140, objects are published. In one method, all servables are published in S concurrently. This avoids consistency problems. Another method publishes some servables in S before others, i.e. incremental publication.



There are a number of reasons why incremental publication may be desirable. These reasons may include:

(1) In a number of environments, publishing documents after the documents are updated may be time-consuming.

5 Incremental publication may make certain documents available sooner than would be the case using the all-at-once approach.

10 (2) It is conceivable that some environments may have constraints on the number of documents which can be published atomically. The incremental approach reduces the number of documents which need to be published in single atomic actions.

15 Incremental publishing may be more difficult to implement than the all-at-once approach because of the need to satisfy consistency constraints such as the ones described earlier.

20 Referring to FIG. 5, a method for incrementally publishing objects, for example, Web pages, which satisfies one or more consistency constraints described earlier is shown. In step 410, a consistency graph is created which includes servables as vertices/nodes. Edges of the

consistency graph are referred to as consistency edges. A consistency edge from a servable c to another servable d indicates that d should not be published before c.

Consistency edges do not imply the order in which c and d are be generated. A consistency edge exists if there were a hypertext link from d to c and both d and c are in S. Such a link does not imply that c must be constructed before d, only that c should be published before or concurrently with d. It is entirely possible that data dependence edges indicate that d should be constructed before c even though c should be published before or at the same time as d.

Consistency edges are also used to indicate that two servables both embed a common fragment whose value has changed and thus are to be published concurrently. If c and d both embed a common fragment whose value has changed, then a consistency edge from c to d and d to c should exist.

It is now explained how to determine whether two servables both embed a common changed fragment. As a node a in S is constructed in the order defined by the topological sort in block 130, a set of comprising-nodes is computed for a. Comprising-nodes(a) includes identifiers for nodes in S

which affect the value of a.  $\text{Comprising-nodes}(a)$  is the union of b and  $\text{comprising-nodes}(b)$  for edges (b,a) which terminate in a where b is a member of S.

A directed graph T is now created including servables  
5 in S (S is the set of all objects which have changed) and consistency edges. For two servables a and b in S, an edge from a to b exists in T if:

- (1) A hypertext link from b to a exists, or
- (2) a and b both embed a common changed fragment. This is  
10 true if  $\text{comprising-nodes}(a)$  and  $\text{comprising-nodes}(b)$  have a node in common. In this case, a consistency edge from both a to b and b to a exist.

In step 420, graph traversal algorithms are used on T to topologically sort T and find its strongly connected  
15 components. A strongly connected component of T is a maximal subset of vertices T' such that every vertex in T' has a directed path to every other vertex in T'. The previously cited book, *Introduction to Algorithms*, by Cormen, et al. includes an algorithm for finding  
20 strongly connected components. Other algorithms for finding strongly connected components may also be employed. Each

strongly connected component of T corresponds to a set of servables which can be published together.

In step 430, servables are published in the following order: Examine servables of T in topological sorting order.  
5 For a servable a of T, if a was part of a previously published strongly connected component, go to the next servable. Otherwise, publish all servables corresponding to the strongly connected component including a in an atomic action.

10 An extension of this algorithm may be to use either more or fewer consistency constraints in the method depicted in FIG 5. Another extension may be to enhance the method to try to prevent publication of pages with broken hypertext links. The present invention may be  
15 extended to the publication of documents including but not limited to Web pages.

A quick publishing and censoring system and method which may be used is described in "METHOD AND SYSTEM FOR RAPID PUBLISHING AND CENSORING INFORMATION", Attorney docket  
20 number Y0999-040(8728-253), filed concurrently herewith, commonly assigned and incorporated herein by reference. A

system and method which may be used for publishing web documents is described in "METHOD AND SYSTEM FOR PUBLISHING DYNAMIC WEB DOCUMENTS", Attorney docket number YO999-039(8728-254), filed concurrently herewith, commonly  
5 assigned and incorporated herein by reference.

Having described preferred embodiments of a system and method for efficiently constructing and consistently publishing web documents (which are intended to be illustrative and not limiting), it is noted that  
10 modifications and variations can be made by persons skilled in the art in light of the above teachings. It is therefore to be understood that changes may be made in the particular embodiments of the invention disclosed which are within the scope and spirit of the invention as outlined by the  
15 appended claims. Having thus described the invention with the details and particularity required by the patent laws, what is claimed and desired protected by Letters Patent is set forth in the appended claims.

**WHAT IS CLAIMED IS:**

1. A method for determining an order in which to construct objects comprising the steps of:

5 providing a plurality of objects, at least one of the objects including a relationship with another object in the plurality of objects;

identifying at least one relationship between the plurality of objects;

10 representing the at least one relationship between the plurality of objects using at least one graph; and

traversing at least one graph to determine the order in which to construct objects in accordance with the at least one relationship and an update to at least one of the  
15 objects in the plurality of objects.

2. The method as recited in claim 1, wherein the step of representing the at least one relationship between the plurality of objects includes the step of representing  
20 objects in the plurality of objects by nodes and

representing the at least one relationship by at least one connection between nodes.

3. The method as recited in claim 1, wherein the step  
5 of traversing at least one graph to determine the order includes the step of selecting the order based on one of performance and correct construction of the plurality of objects.

10 4. The method as recited in claim 1, wherein the step of traversing at least one graph to determine the order includes the step of traversing by employing at least one topological sort on the at least one graph.

15 5. The method as recited in claim 4, wherein the order is constructed from the at least one topological sort.

20 6. The method as recited in claim 1, further comprising the step of constructing objects based on the order.

7. The method as recited in claim 1, further comprising the step of publishing at least one of the plurality of objects.

5 8. The method as recited in claim 7, wherein all of the at least one of the plurality of objects are published together.

10 9. The method as recited in claim 7, wherein the step of publishing includes the steps of:

partitioning the at least one of the plurality of objects into a plurality of groups; and

publishing all objects belonging to a same group together.

15 10. The method as recited in claim 9 wherein the step of publishing all objects belonging to a same group together includes the step of:

20 for at least two of the plurality of groups, publishing all objects belonging to a first group before publishing any objects belonging to a second group.



11. The method as recited in claim 7, wherein the step of publishing includes the step of satisfying at least one consistency constraint.

5 12. The method as recited in claim 11, wherein the step of satisfying at least one consistency constraint includes the step of delaying publication of a first object until a second object which is referenced by the first object is published.

10 13. The method as recited in claim 12, wherein the first object and the second object include Web pages and a reference between the first and second objects includes a hypertext link.

15 14. The method as recited in claim 11, wherein the step of satisfying at least one consistency constraint includes the step of publishing two compound objects together if the compound objects are both constructed from  
20 at least one common changed fragment.

15. The method as recited in claim 1, wherein at least one of the plurality of objects is a Web page.

16. A method for publishing a plurality of objects comprising the steps of:

providing a plurality of objects, including compound objects;

partitioning at least some of the plurality of objects into a plurality of groups such that if two compound objects are constructed from at least one common changed fragment, then the compound objects are placed in a same group; and

publishing all objects belonging to a same group together.

17. The method as recited in claim 16, wherein the step of publishing includes the step of:

for at least two of the plurality of groups, publishing all objects belonging to a first group before publishing any objects belonging to a second group.

18. The method as recited in claim 16, wherein the step of publishing includes the step of:

delaying publication of a first object until a second object which is referenced by the first object is published.

5

19. The method as recited in claim 18, wherein the first and the second objects are Web pages and a reference between the first and the second objects is a hypertext link.

10

20. The method as recited in claim 16, further comprising the steps of:

representing objects by nodes on at least one graph;  
and

15

representing relationships between the objects by connections between the nodes.

21. The method as recited in claim 20, wherein the connections include an edge between two nodes representing compound objects if the two compound objects are constructed from at least one common changed fragment.

20

22. The method as recited in claim 20, wherein the connections include a directed edge from a first node representing a first object to a second node representing a second object, if the second object includes a reference to the first object.

23. The method of claim 20, further comprising the steps of:

determining if a first compound object and a second compound object embed at least one common changed fragment by:

topologically sorting at least part of a graph including dependence edges between objects;

determining changed fragments needed to construct a first object by:

examining the graph in an order defined by the topological sort; and

constructing a union between a second object and changed fragments needed to construct the second object for at least one edge which begins with the second object

and terminates in the first object and for which the second object has changed.

24. The method as recited in claim 20 further  
5 comprising the step of performing a topological sort on at least part of the at least one graph for finding strongly connected components.

25. The method as recited in claim 24, further  
10 comprising the step of publishing a set objects belonging to a same strongly connected component, of the at least one graph, together.

26. The method as recited in claim 24, further  
15 comprising the steps of:

examining objects in an order defined by the  
topological sort;

when an unpublished object is examined, publishing the  
unpublished object together with all objects belonging to a  
20 same strongly connected component.

27. A program storage device readable by machine,  
tangibly embodying a program of instructions executable by  
the machine to perform method steps for determining an order  
in which to construct a plurality of objects, the method  
5 steps comprising:

providing a plurality of objects, at least one of the  
objects including a relationship with another object in the  
plurality of objects;

10 identifying at least one relationship between the  
plurality of objects;

representing the plurality of objects and the at least  
one relationship between the plurality of objects using at  
least one graph; and

15 traversing at least one graph to determine the order in  
which to construct objects in accordance with the at least  
one relationship and an update to at least one of the  
objects in the plurality of objects.

20 28. The program storage device as recited in claim 27,  
wherein the step of graphically representing the at least  
one relationship between the plurality of objects includes

the step of representing objects in the plurality of objects by a node and representing the at least one relationship by a connection between nodes.

5           29. The program storage device as recited in claim 27, wherein the step of traversing at least one graph to determine the order includes the step of selecting the order based on one of performance and correct construction of the plurality of objects.

10           30. The program storage device as recited in claim 27, wherein the step of traversing at least one graph to determine the order includes the step of traversing by employing at least one topological sort on at least part of  
15 the at least one graph.

20           31. The program storage device as recited in claim 30, wherein the order is constructed from the at least one topological sort.

32. The program storage device as recited in claim 27,  
further comprising the step of constructing the plurality of  
objects based on the order.

5           33. The program storage device as recited in claim 27,  
further comprising the step of publishing at least one of  
the plurality of objects.

10           34. The program storage device as recited in claim 33,  
wherein all of the at least one of the plurality of objects  
are published together.

15           35. The program storage device as recited in claim 33,  
wherein the step of publishing includes the steps of:

partitioning the at least one of the plurality of  
objects into a plurality of groups; and

publishing all objects belonging to a same group  
together.



36. The program storage device as recited in claim 35 wherein the step of publishing all objects belonging to a same group together includes the step of:

for at least two of the plurality of groups, publishing  
5 all objects belonging to a first group before publishing any objects belonging to a second group.

37. The program storage device as recited in claim 33,  
wherein the step of publishing includes the step of  
10 satisfying at least one consistency constraint.

38. The program storage device as recited in claim 37,  
wherein the step of satisfying at least one consistency  
15 constraint includes the step of delaying publication of a first object until a second object which is referenced by the first object is published.

39. The program storage device as recited in claim 38,  
20 wherein the first object and the second object include Web

pages and a reference between the first and second objects includes a hypertext link.

40. The program storage device as recited in claim 37,  
5 wherein the step of satisfying at least one consistency constraint includes the step of publishing two compound objects together if the compound objects are both constructed from at least one common changed fragment.

10 41. The program storage device as recited in claim 27, wherein at least one of the plurality of objects is a Web page.

15 42. A program storage device readable by machine, tangibly embodying a program of instructions executable by the machine to perform method steps for publishing a plurality of objects, the method steps comprising:

providing a plurality of objects, including compound objects;

20 partitioning at least some of the plurality of objects into a plurality of groups such that if two compound objects

are constructed from at least one common changed fragment,  
then the compound objects are placed in a same group; and  
publishing all objects belonging to a same group  
together.

5

43. The program storage device as recited in claim 42,  
wherein the step of publishing includes the step of:

for at least two of the plurality of groups, publishing  
all objects belonging to a first group before publishing any  
objects belonging to a second group.

10

44. The program storage device as recited in claim 42,  
wherein the step of publishing includes the step of:

delaying publication of a first object until a second  
object which is referenced by the first object is published.

15

45. The program storage device as recited in claim 44,  
wherein the first and the second objects are Web pages and a  
reference between the first and second objects is a  
hypertext link.

20

46. The program storage device as recited in claim 44,  
further comprising the steps of:

representing objects by nodes on at least one graph;  
and

5 representing relationships between the objects by  
connections between the nodes.

47. The program storage device as recited in claim 46,  
wherein the connections include an edge between two nodes  
10 representing compound objects if two compound objects are  
constructed from at least one common changed fragment.

48. The program storage device as recited in claim 46,  
wherein the connections include a directed edge from a first  
15 node representing a first object to a second node  
representing a second object, if the second object includes  
a reference to the first object.

49. The program storage device of claim 46, further  
20 comprising the steps of:

determining if a first compound object and a second compound object embed at least one common changed fragment by:

topologically sorting a graph including dependence edges between objects;

determining changed fragments needed to construct a first object by:

examining the graph in an order defined by the topological sort; and

constructing a union between a second object and changed fragments needed to construct the second object for at least one edge which begins with the second object and terminates in the first object and for which the second object has changed.

50. The program storage device as recited in claim 46, further comprising the step of performing a topological sort on at least part of the at least one graph for finding strongly connected components.

51. The program storage device as recited in claim 50, further comprising the step of publishing a set objects belonging to a same strongly connected component, of the at least one graph, together.

5

52. The method as recited in claim 50, further comprising the steps of:

examining objects in an order defined by the topological sort;

when an unpublished object is examined, publishing the unpublished object together with all objects belonging to a same strongly connected component.

53. A method for publishing a plurality of objects comprising the steps of:

providing a plurality of objects;

constructing at least one graph, the at least one graph including nodes representing objects and edges for connecting nodes having relationships, at least some of the edges being derived from at least one consistency constraint; and

finding at least one strongly connected component in  
the at least one graph.

54. The method as recited in claim 53, further  
5 comprising the step of publishing a set of objects belonging  
to a same strongly connected component group.

55. The method as recited in claim 53, further  
comprising the step of topologically sorting at least part  
10 of the at least one graph.

56. The method as recited in claim 55, further  
comprising the steps of:

examining objects in an order defined by topological  
15 sorting;

when an unpublished object is examined, publishing the  
unpublished object together with all objects belonging to a  
same strongly connected component.

20 57. The method as recited in claim 53, wherein one of  
the at least one consistency constraint includes delaying

publication of a first object before a second object which is referenced by the first object is published.

58. The method as recited in claim 57, wherein the first and second objects include Web pages and at least one edge between the objects corresponds to at least one hypertext link.

59. The method as recited in claim 53, wherein an edge exists from a first object to a second object in at least one of the at least one graphs if the second object has a reference to the first object.

60. The method as recited in claim 53, wherein at least one of the consistency constraints includes publishing two compound objects together if the two compound objects are both constructed from at least one common changed fragment.



METHOD AND SYSTEM FOR EFFICIENTLY CONSTRUCTING AND  
CONSISTENTLY PUBLISHING WEB DOCUMENTS

ABSTRACT OF THE DISCLOSURE

5           A method, which may be implemented by employing a  
program storage device, for determining an order in which to  
construct objects, in accordance with the present invention,  
includes the steps of providing a plurality of objects, at  
least one of the objects including a relationship with  
10 another object in the plurality of objects, identifying at  
least one relationship between the plurality of objects,  
representing the at least one relationship between the  
plurality of objects using at least one graph, and  
traversing at least one graph to determine the order in  
15 which to construct objects in accordance with the at least  
one relationship and an update to at least one of the  
objects in the plurality of objects.

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

**APPLICANT(S):** James R.H. Challenger, Cameron Ferstat, Arun K. Iyengar,  
Paul Reed, Karen A. Witting

**SERIAL NO.:** Unassigned

**FILED:** Concurrently herewith

**FOR:** METHOD AND SYSTEM FOR EFFICIENTLY  
CONSTRUCTING AND CONSISTENTLY PUBLISHING  
WEB DOCUMENTS

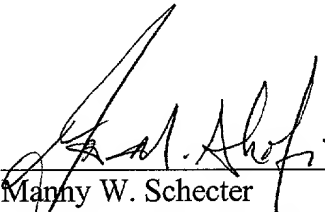
**ASSOCIATE POWER OF ATTORNEY**

Please recognize **FRANK CHAU**, Reg. No. 34,136; **JAMES J. BITETTO**, Reg. No. 40,513; **FRANK V. DeROSA**, Reg. No. 43,584; and **GASPARE J. RANDAZZO**, Reg. No. 41,528; each of them of **F. CHAU & ASSOCIATES, LLP**, 1900 Hempstead Turnpike, Suite 501, East Meadow, New York 11554 as associate attorneys in the above-mentioned application, with full power to prosecute said application, to make alterations and amendments therein, and to transact all business in the Patent and Trademark Office connected therewith.

Telephone calls should be made to Frank Chau by dialing (516) 357-0091.

All written communications are to be sent to Frank Chau, Esq.,  
**F. Chau & Associates, LLP, 1900 Hempstead Turnpike, Suite 501, East Meadow,  
New York 11554.**

International Business Machines  
Corporation  
T.J. Watson Research Center  
Route 134 and Kitchawan Road  
Yorktown Heights, New York 10598

  
Manny W. Schecter  
Registration No. 31,722  
David M. Shofi  
Registration No. 39,835  
Attorney for Applicant(s)

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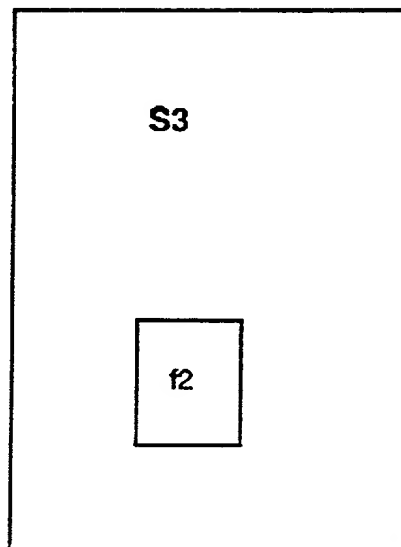
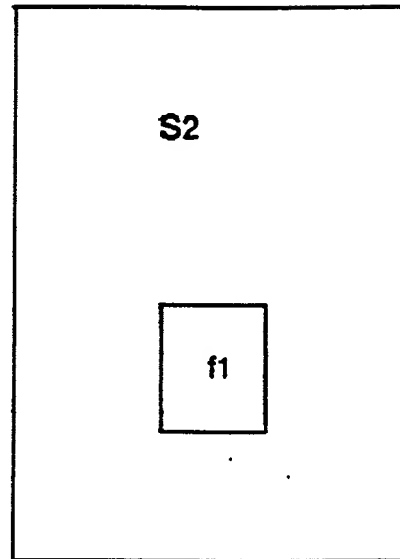
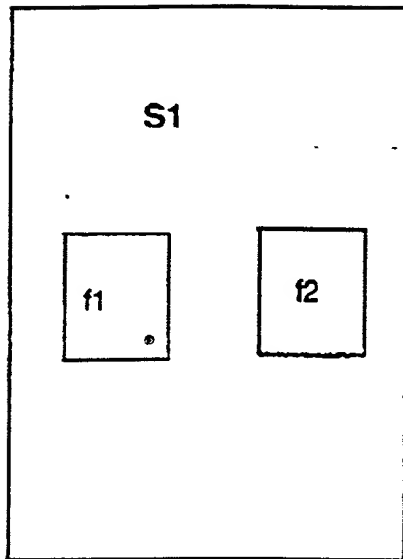


FIG. 1

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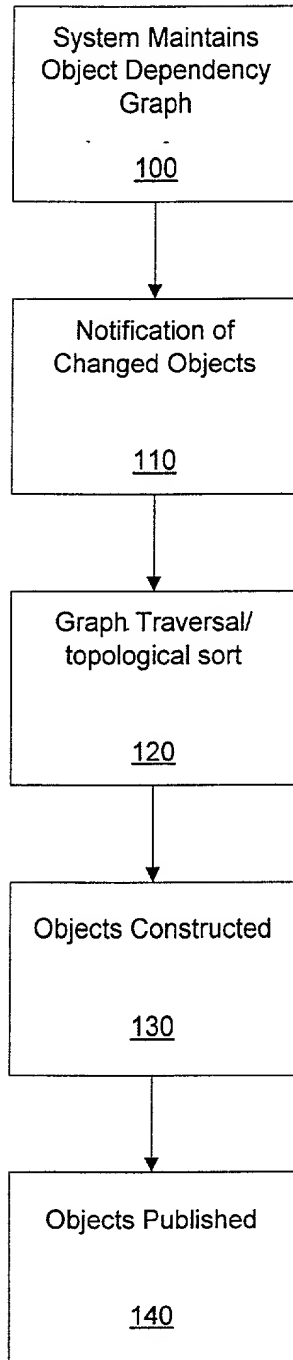


FIG. 2

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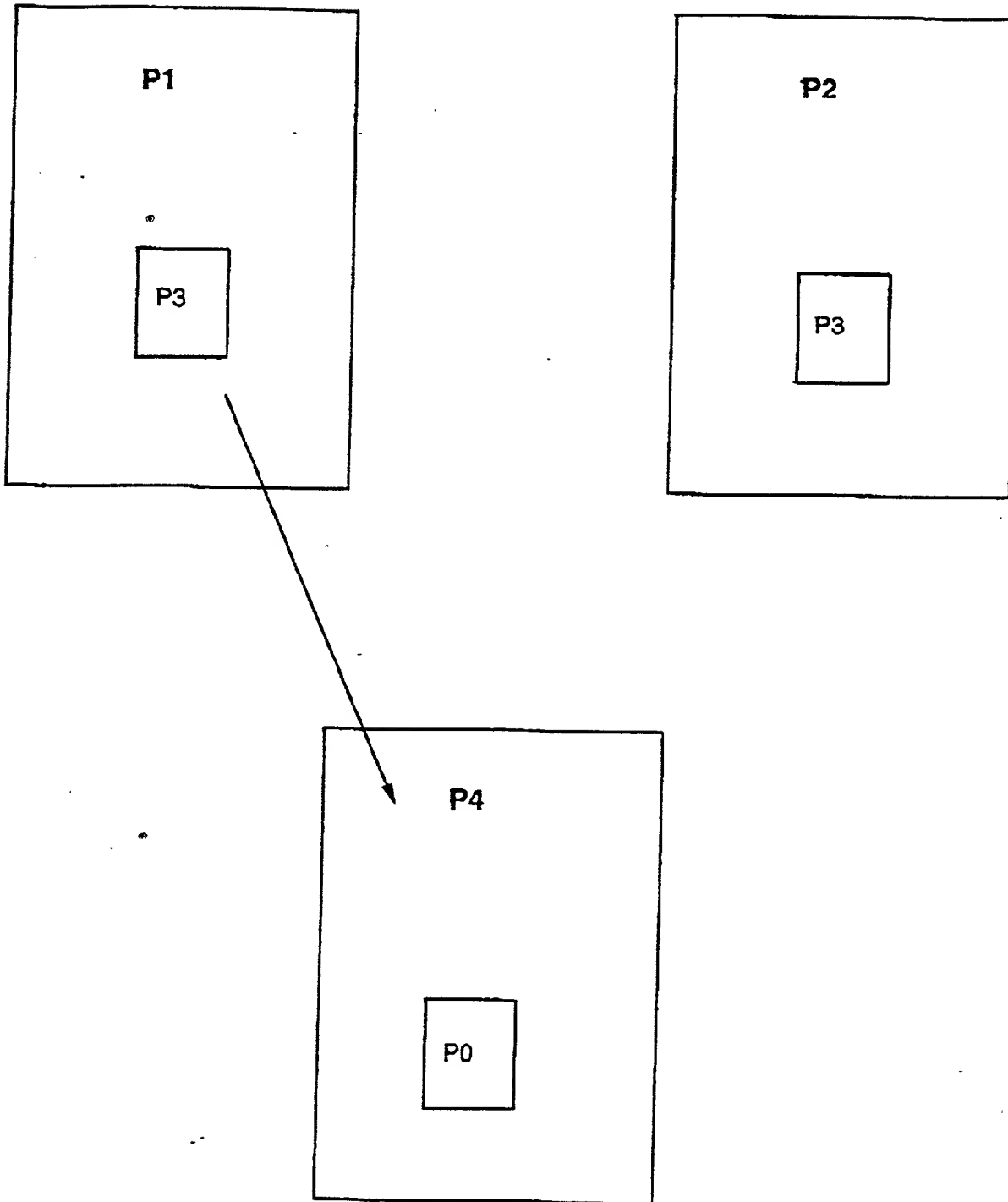


FIG. 3

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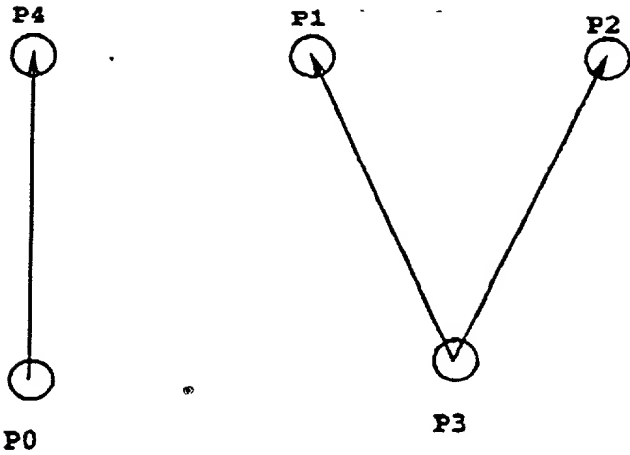


FIG. 4

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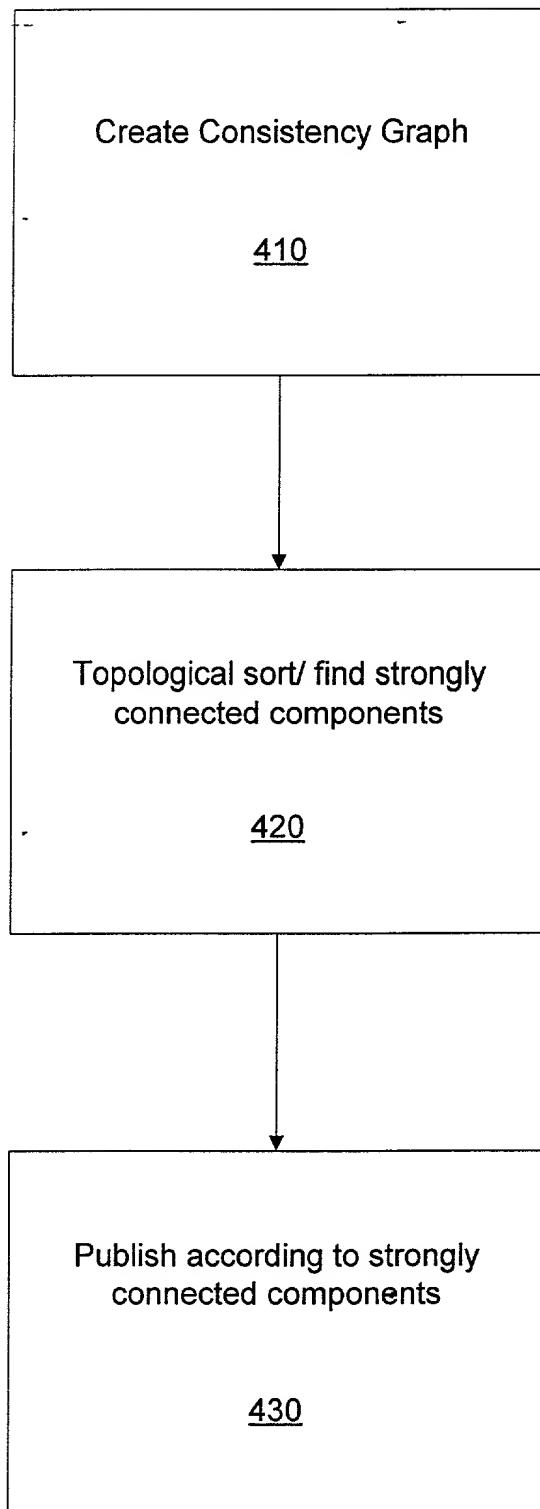


FIG. 5

AS A BELOW NAMED INVENTOR, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe that I am the original, first and sole (*if only one name is listed below*), or an original, first and joint inventor (*if plural names are listed below*), of the subject matter which is claimed and for which a patent is sought on the invention entitled:

**TITLE: METHOD AND SYSTEM FOR EFFICIENTLY CONSTRUCTING AND CONSISTENTLY PUBLISHING WEB DOCUMENTS**

the specification of which either is attached hereto or indicates an attorney docket no. YO999-011 (8728-255), or:

☐ was filed in the U.S. Patent & Trademark Office on \_\_\_\_\_ and assigned Serial No. \_\_\_\_\_,

☐ and (*if applicable*) was amended on \_\_\_\_\_,

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to patentability and to the examination of this application in accordance with Title 37 of the Code of Federal Regulations §1.56. I hereby claim foreign priority benefits under Title 35, U.S. Code §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States, or §119(e) of any United States provisional application(s), listed below and have also identified below any foreign applications for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

**Priority Claimed:**

Yes [ ] No [ ]

\_\_\_\_\_  
(Application Number) (Country) (Day/Month/Year filed)

Yes [ ] No [ ]

\_\_\_\_\_  
(Application Number) (Country) (Day/Month/Year filed)

I hereby claim the benefit under Title 35, U.S. Code, §120, of any United States application(s), or §365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application(s) in the manner provided by the first paragraph of Title 35, U.S. Code, §112, I acknowledge the duty to disclose information material to patentability as defined in Title 37, The Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

\_\_\_\_\_  
(Application Serial Number) (Filing Date) (STATUS: patented, pending, abandoned)

\_\_\_\_\_  
(Application Serial Number) (Filing Date) (STATUS: patented, pending, abandoned)

I hereby appoint the following attorneys: **MANNY W. SCHECTER**, Reg. No. 31,722; **TERRY ILARDI**, Reg. 29,936; **CHRISTOPHER A. HUGHES**, Reg. No. 26,914; **EDWARD A. PENNINGTON**, Reg. No. 32,588; **JOHN E. HOEL**, Reg. No. 26,279; **JOSEPH C. REDMOND, Jr.**, Reg. No. 18,753; **ROBERT P. TASSINARI, Jr.**, Reg. No. 36,030; **DOUGLAS W. CAMERON**, Reg. No. 31,596; **KEVIN M. JORDAN**, Reg. No. 40,277; **STEPHEN C. KAUFMAN**, Reg. No. 29,551; **DANIEL P. MORRIS**, Reg. No. 32,053; **LOUIS J. PERCELLO**, Reg. No. 33,206; **JAY SBROLLINI**, Reg. No. 36,266; **ROBERT M. TREPP**, Reg. No. 25,933; **DAVID M. SHOFL**, Reg. No. 39,835; **LOUIS P. HERZBERG**, Reg. No. 41,500; and **PAUL J. OTTERSTEDT**, Reg. No. 37,411, each of them of **INTERNATIONAL BUSINESS MACHINES CORPORATION**, Thomas J. Watson Research Center, P.O. Box 218, Yorktown Heights, New York 10598; to prosecute this application and to transact all business in the U.S. Patent and Trademark Office connected therewith and with any divisional, continuation, continuation-in-part, reissue or re-examination application, with full power of appointment and with full power to substitute an associate attorney or agent, and to receive all patents which may issue thereon, and request that all correspondence be addressed to:

Frank Chau, Esq.  
F. CHAU & ASSOCIATES, LLP  
1900 Hempstead Turnpike, Suite 501  
East Meadow, New York 11554  
Tel.: 516-357-0091




HEREBY DECLARE that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 U.S. Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.


FULL NAME OF FIRST OR SOLE INVENTOR: James R.H. Challenger Citizenship USA

Inventor's signature:  Date: 3-30-99  
Residence & Post Office Address: 404 Old West Point Road, Garrison, NY 10524


FULL NAME OF SECOND JOINT INVENTOR: Cameron Ferstat Citizenship Australia

Inventor's signature:  Date: 3-30-99  
Residence & Post Office Address: 11 Francis Street, Sleepy Hollow, NY 10591

FULL NAME OF THIRD JOINT INVENTOR: Arun K. Iyengar Citizenship USA

Inventor's signature:  Date: 3/30/99  
Residence & Post Office Address: 1160 Park Lane, Yorktown Heights, NY 10598

FULL NAME OF FOURTH JOINT INVENTOR: Paul Reed Citizenship British

Inventor's signature:  Date: 7/30/99  
Residence & Post Office Address: 321 Halstead Avenue, Apt. #3, Harrison, NY 10528

FULL NAME OF FIFTH JOINT INVENTOR: Karen A. Witting Citizenship USA

Inventor's signature:  Date: 3/30/99  
Residence & Post Office Address: 1A Knollwood Drive, Ossining, NY 10562

FULL NAME OF SIXTH JOINT INVENTOR: \_\_\_\_\_ Citizenship \_\_\_\_\_

Inventor's signature: \_\_\_\_\_ Date: \_\_\_\_\_  
Residence & Post Office Address: \_\_\_\_\_